

SHS Course

Philosophical Perspectives on the Exact Sciences I+II

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The goal of this master programme is to acquire the skills necessary to address philosophical questions that arise from the exact sciences and their history. This includes questions such as:

- How do the visions of space and time change from Newton to Einstein?
- What is matter following the revolution brought about by quantum physics?
- What is a law of nature?
- Do mathematical objects really exist?
- Does artificial intelligence really think?

These questions, among many others, will be tackled in the philosophical and historical reflections on the exact sciences that this master module offers. These reflections provide intellectual tools for a better understanding of modern science and technology. After a series of introductory lectures, the students work in small groups of 2 to 5 people to prepare a philosophical essay on a topic from the philosophy or history of science. Students can freely choose their topic of interest – in coordination with a supervisor – but are encouraged to work on a philosophical project related to their field of study at EPFL.

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Contents

I. Organization	1
1. Supervisors	1
2. The Programme	1
3. What You Are Expected to Do	2
3.1. The Essay Plan	2
3.2. Grading autumn term	2
3.3. The Essay	3
4. Schedule	5
5. How to Write an Essay?	6
6. Online Resources	7
II. The Projects	7
7. Proposed Research Projects	8
7.1. What Is a Law of Nature?	8
7.2. Newton vs. Leibniz on Space, Time, and Motion	8
7.3. What is Light?	9
7.4. Entropy and the Arrow of Time	9
7.5. The Twin Paradox	10
7.6. Space-Time in General Relativity	11
7.7. Is Time Travel Possible?	11
7.8. Bell's Theorem and Quantum Nonlocality	12
7.9. The Quantum Measurement Problem	12
7.10. Interpretations of Quantum Mechanics	13
7.11. Bohmian Mechanics	13
7.12. The Many-Worlds Theory	14
7.13. Do Mathematical Objects Exist?	14
7.14. The Success of Mathematics in the Natural Sciences	15
7.15. Could Machines Think?	15
7.16. Artificial Intelligence and its Consequences	16
7.17. Is Free Will compatible with Laws of Nature?	16
7.18. Free Will and Neuroscience	17
7.19. Can Science Explain Consciousness?	18

Part I.

Organization

1. Supervisors

Teaching assistant for this course is Amine Rusi (amine.rusielhassani@unil.ch). He is at your disposal for any questions regarding the course and will supervise most of the projects. Further teachers and supervisors of projects are

- Alin Cucu (Alin.Cucu@unil.ch)
- Dr. Cristian Lopez (cristian.lopez@unil.ch)

One of them will be assigned as a supervisor to your group and assist you in preparing the essay.

2. The Programme

The goal of the master programme is to acquire the skills necessary to address the philosophical questions that are raised by the exact sciences and their history. You choose a project and work in groups of *2–5 students*. By the end of the autumn term, you prepare an essay plan and defend it in a short presentation. During the spring term, you write an essay following your plan. You can freely choose among the projects proposed in Part II of this manual or choose a topic of your own in consultation with the supervisor. You are welcome to choose a topic that discusses philosophical issues in your field of study at EPFL. We propose projects in the following seven fields:

- Metaphysics of Physics,
- Philosophy and History of Classical Physics,
- Philosophy of Relativistic Physics,
- Philosophy and History of Quantum Mechanics,
- Philosophy of Mathematics,
- Philosophy of Mind,
- Philosophy of Computer Science and AI.

If you wish to work on a topic that is not listed in this manual, please contact Amine Rusi.

3. What You Are Expected to Do

1. Follow the introductory lectures starting on 21 September 2022.
2. Find a group and a project by 26 October 2022.
3. Submit an essay plan at least 7 days before the oral presentation.
4. Present your essay plan in a short presentation (approx. 15 min. talk + 15 min. discussion) at the end of the autumn term.
5. Submit a first complete version of the essay by 1 May 2023.
6. Submit final version of the essay, after receiving feedback on the first draft, by 1 June 2023.

3.1. The Essay Plan

The essay plan is intended to help you prepare your essay. It should comprise 600–800 words (excluding references) written in complete sentences. It should include

1. the working title of your essay,
2. your names,
3. the last date when you revised the essay plan,
4. an introduction,
5. your research question(s),
6. how you're going to address the question(s), and
7. a list of references.

Send your essay plan to your supervisor at least 7 days before your oral presentation. The preferred format is PDF. You can write the essay plan in English or French and, depending on the supervisor, also in German. The oral presentations of the plan will take place in December (exact schedule will be announced). You may use electronic slides (e.g., PowerPoint).

3.2. Grading autumn term

You will receive a grade for the autumn term based on the submitted essay plan and the oral presentation, including the discussion. You don't have to master all the details of your topic as this will probably be your first encounter with philosophy of science. But we expect you to outline a clear and convincing project and demonstrate an understanding of the most important aspects of the topic and philosophical questions you are going to address.

3.3. The Essay

Target

You write a philosophical essay that should be understandable for a reader with basic knowledge in the respective field. The essay *can* include a technical part but *must* address a philosophical question. Technical terms or results requiring more than basic knowledge should be explained to the reader. You are not expected to produce original results, but demonstrate a good understanding of the essay topic and your own reflections about it.

Language

You may write your essay in English, French or German, although English is recommended. Since almost all the relevant publications are in English, this will make it easier for you to work with references and allow you to practice scientific writing.

Regardless of the language you choose, proper style and spelling are important. We take into consideration that you may not be writing in your native tongue, but clear and precise formulations matter in philosophical writing.

Structure

Your essay should include the following elements:

- title,
- names of the authors,
- date of last update,
- abstract (≤ 150 words),
- word count,
- main text (introduction, core sections, conclusion),
- bibliography.

The abstract should briefly summarize the main content and results of your paper. The main text consists of several sections. The first section is always an introduction to the topic. After the introduction, you present your investigation into the respective topic, relying on pertinent literature to develop arguments and work out possible answers to the central research questions. Papers in philosophy and in the natural sciences can differ in this respect. For philosophical papers, it is considered good practice to present different opposing positions and discuss the respective arguments and counter-arguments. However, you don't have to remain "neutral". Evaluate the arguments critically and don't be afraid to state and defend your own position, as this usually makes your paper more interesting and original. The last section should summarize

the main conclusions of your paper. Try not to be too repetitive but focus on the more novel results, interesting ideas, or open questions arising from your discussion. In the end, your essay should look like a professional research paper in the philosophy of physics, mathematics, or artificial intelligence.

Length

There is *no firm word limit or minimal word count*. The *suggested* word count depends on the number of authors contributing to your essay:

- 1 author: 4000–5000 words,
- 2 authors: 5000–6000 words,
- 3 authors: 6000–7500 words.

The word count includes everything in the main text, headings, quotes and footnotes, but not the abstract and bibliography. Every member of the group is expected to make a substantial contribution to the final essay.

Citations

Please use an *author-year citation format* (e.g., APA, Chicago, Harvard, ...). Don't reference publications by numbers or abbreviations. Complete and precise references are important. Citations that are not indicated as such (e.g., copying from the internet) constitute plagiarism.

Grading

We will grade your essay based on the following criteria:

- Did you demonstrate a good understanding of your research topic and the related philosophical debates?
- Did you develop clear/interesting/compelling arguments?
- Did you consider relevant literature?
- Does your essay satisfy the formal requirements (e.g., correct citation)?
- Is your essay written in a good style and correct language?

Submission

Please send a complete version of your essay to your supervisor by **1 May 2023**. We only accept PDF or Word documents. Please use the official cover page that you can download from the website of the SHS programme. You will receive feedback on this submission and have the chance to make corrections. The final version that will be graded is due on **1 June 2023**.

One-term projects

Under certain circumstances (e.g., for exchange students visiting EPFL for a limited time), it is possible to attend only part I of the course and complete the essay in one semester. Please e-mail Amine Rusi in case you take the course only in the autumn term.

4. Schedule

Autumn Term '22

The autumn term is divided into three parts:

1. Lectures

Location: Room INR 219, Wed 16-19h.

21 September

16h15-17h30: Introduction to the programme and Newton on natural philosophy. (Prof. Michael Esfeld)

17h45-18h45: Physics and philosophy. (Dr. Cristian Lopez)

28 September

16h15-17h30: Philosophy of space and time: Leibniz vs. Newton (Prof. Michael Esfeld)

17h45-18h45: What is a law of nature? (Prof. Michael Esfeld)

5 October

16h15-17h30: Quantum physics: non-locality and the measurement problem. (Prof. Michael Esfeld)

17h45-18h45: The ontology of quantum physics. (Prof. Michael Esfeld)

12 October

16h15-17h30: Philosophy of artificial intelligence and consciousness. (Alin Cucu)

17h45-18h45: Mind and free will. (Prof. Michael Esfeld)

19 October

16h15-17h30: Mathematical structure and ontology. (Dr. Cristian Lopez)

17h45-18h45: How to write an essay. (Amine Rusi)

2. Preparation of the Essay Plan

- No lectures until the presentations.
- Definite fixing of the groups and essay topics by **Wednesday 26 October**.

- One compulsory meeting with your supervisor, further meetings upon request. Meetings can be scheduled via moodle.
- Submit the essay plan to your supervisor at least one week before your presentation.

3. Presentations

Presentations of essay plans: 15 minutes presentation + 15 minutes discussion. There will be four sessions on Wednesdays, 16h15-19h15, on

- 30 November,
- 7 December,
- 14 December,
- 21 December,

The exact presentation schedule will be posted on moodle.

Spring Term '23

During the spring term, you are supposed to work on your essay. There will be no lectures, but you are required to *meet your supervisor at least twice* to discuss your project. We also recommend that you have regular contact with the other members of your group to discuss your topic and coordinate your work.

1. Intermediate session I in February and March.
2. Intermediate session II in April.
3. Final feedback in May.

Starting from the beginning of the spring term, you will be able to schedule meetings with your supervisor via moodle. Further meetings are available upon request. Submit a first complete draft of your essay by **1 May 2023**. Your supervisor will give you feedback. If your essay needs improvement, you can submit a revised and final version until **1 June 2023**.

5. How to Write an Essay?

Style

Writing is a skill that you can only achieve through regular practice and proper teaching. Before preparing your essay, please read the [guidelines on writing a paper](#) by the philosopher Jim Pryor from NYU. If you're interested in improving your writing skills in general, **Sword:2012aa** is a good reference for academic writing.

Spelling and Punctuation

The English language has its own rules of punctuation. Good punctuation gives a clear structure to your text and helps the reader to grasp the correct meaning of a sentence.

Trask:1997aa is a primer on English punctuation. Good online dictionaries are for example:

- the [Oxford Dictionary of English](#) (ODE),
- the [Oxford Advanced Learner’s Dictionary](#) (OALD).

The OALD uses easier explanations and contains simpler examples. Also, a thesaurus can be very helpful for improving your vocabulary. The ODE contains a huge database of synonyms. Software like *Grammarly* or the spell check in *Microsoft Word* can help you find and correct mistakes in grammar in spelling.

6. Online Resources

Open peer-reviewed sources on the internet are:

- [The Stanford Encyclopedia of Philosophy](#) (SEP).
- [The Internet Encyclopedia of Philosophy](#) (IEP).
- [Scholarpedia](#).

The SEP, in particular, is a comprehensive and widely-used encyclopedia containing articles on a wide range of philosophical topics. It is also a good starting point for finding further references. The IEP articles are also very helpful and usually more accessible. Scholarpedia contains many good entries on topics from physics.

We strongly recommend not to use other online sources unless you arrange this with your supervisor. Many websites contain imprecise or even wrong information. In particular, Wikipedia is not a scientific resource! While it can be useful to get a quick overview of a topic or keyword, the quality of the articles varies and most do not meet scientific standards.

Part II.

The Projects

Below, we propose a number of topics that are relevant to the contemporary discourse in philosophy and well suited for a two-term project. You can also choose any of the “propositions de travail” included in the textbook “Philosophie des sciences. Une introduction” by Michael Esfeld ([esfeld2017](#)). The second part of this book is a primer

on many of the topics stated below. If you want to work on a different subject not mentioned in the book or this manual, you can formulate your own research topic in consultation with your supervisor.

7. Proposed Research Projects

7.1. What Is a Law of Nature?

Fundamental physics studies the laws of nature. But what exactly are “laws of nature”? The great debate in contemporary philosophy of science is roughly between the “regularity view” and the “governing view” of laws. The first, also known as *Humeanism* or the *Best System Account*, holds that laws are merely descriptive, an efficient summary of contingent regularities that we find in the world. The opposing, anti-Humean views, hold that laws do actually govern or guide or produce what happens in the world. One important elaboration of the governing view is called dispositionalism and holds that there exist fundamental (causal) properties in the world that determine the behavior of matter.

Suggested References

esfeld.deckert2017. Section 2.3

Lange:2002ys. Chapter 3

loewer1996

loewer2012a

maudlin2007

Online Lectures

- [How Theory Meets Data](#) by Tim Maudlin.
- [What Theories Qualify as Quantum Theories without Observers?](#) by Tim Maudlin.
- [A Physicist Looks at Idealism and Relativism](#) by Jean Bricmont.

7.2. Newton vs. Leibniz on Space, Time, and Motion

What is the nature of time and space? Are space and time absolute? Does space exist independently of the objects populating it, or does it reduce to spatial relations between physical entities? This, in brief, was the subject of the epic debate between Isaac Newton (1643–1727) and Gottfried Wilhelm Leibniz (1646–1717). The question

remains highly relevant even today and must be consistently reevaluated on the basis of our best physical theories.

Suggested References

Huggett:1999fk. Chapters 7–8

Maudlin:2012fk. Chapters 1–2

7.3. What is Light?

The existence of “light” is in some sense obvious. We can see it, we can manipulate it, we can do experiments with it. However, if we look at our physical theories, the role of “light” or, more generally, the electromagnetic field is really to mediate interactions between particles. So what exactly is the electromagnetic field and why should we believe in its “reality”? In fact, there exists a formulation of classical electrodynamics (Wheeler-Feynman electrodynamics) in terms of direct particle interactions that involves no fields at all. The main motivation for considering such a theory is that the concept of fields as mediators of particle interactions is problematic, leading in particular to self-interaction singularities, where the strength of the field, acting back on a point particle, becomes infinite. Investigating the status of the electromagnetic field is thus an interesting and important problem from both a physical and a philosophical point of view.

Suggested References

Lange:2002ys

lazarovici2018

Mundy:1989aa

Wheeler:1945aa

7.4. Entropy and the Arrow of Time

Why is there an arrow of time in our universe which seems to be guided, on the fundamental level, by time-symmetric microscopic laws? The most promising answer was given by Ludwig Boltzmann who laid the foundations of statistical mechanics and provided a microscopic explanation of the second law of thermodynamics, establishing irreversible macroscopic behavior characterized by an increase of entropy.

Understanding Boltzmann’s insights is a subtle but important issues. Moreover, there are at least two difficult and controversial debates surrounding the thermodynamic arrow of time. For one, the Boltzmannian account of the thermodynamic arrow requires the assumption that our universe started in an extremely unlikely, low-entropy state. What

is the status of this “Past Hypothesis”? Is it a law of nature? Does it have to be explained? Finally, the question remains whether the thermodynamic asymmetry is sufficient to explain the difference between “past” and “future” or whether there exists a primitive directionality or “flow” of time.

Suggested References

albert2009

bricmont1995

carroll2010

Goldstein:2001aa

Lazarovici:2015aa

penrose1999. Chapter 7

Online Lectures

- [Time’s Arrow and Entropy: Classical and Quantum](#) by Joel Lebowitz.
- [Introduction to Thermodynamics and Statistical Mechanics](#) by David Albert.
- [The Reversibility Objections and the Past Hypothesis](#) by David Albert.
- [The Epistemic and Causal Arrows of Time](#) by David Albert.

7.5. The Twin Paradox

One of two twins leaves in a space shuttle that travels close to the speed of light. When he returns, he finds that his twin brother has aged much more than he did. This, in short, is the infamous “twin paradox” that illustrates one of the most counterintuitive features of Einstein’s theory of special relativity. While many false explanations are presented in physics textbooks, a proper analysis of the phenomenon yields deep insights into the nature of relativistic spacetime.

Suggested References

brown2007

Geroch:1978aa. Chaps. 1, 5, and 6

Maudlin:2012fk. Chapter 4

7.6. Space-Time in General Relativity

Einstein's theory of general relativity is our current best theory of spacetime. Geroch (1978, Chap. 7 and 8) and Maudlin (2012) are good conceptual introductions that use only little mathematics. From there you can go in two directions. One problem is to analyze whether general relativity is committed to space-time as a substance (similar to Newton's absolute space) or to a relational space-time (in the tradition of Leibniz). Another question is whether there is some sort of indeterminism in general relativity. The *hole argument*, originally formulated by Einstein and discussed in detail by Earman (1987), plays an important role in both discussions.

Suggested References

Earman:1987aa

Geroch:1978aa. Chap. 7 and 8

Hoefer:1996aa

Maudlin:1990aa

Maudlin:2012fk. Chapter 6

Online Lectures

[Einstein's Discovery of the General Theory of Relativity](#) by John Norton.

7.7. Is Time Travel Possible?

Some solutions of General Relativity contain "closed time-like curves" that would allow for time travel. But is time travel really possible in our actual universe? Arntzenius and Maudlin (2002) discuss this issue. Their article is also [an entry](#) in the Stanford Encyclopedia of Philosophy.

Suggested References

Arntzenius:2002aa

deutsch1991

deutsch.lockwood2016

7.8. Bell's Theorem and Quantum Nonlocality

Bell's theorem shows that nonlocality is a physical feature of our world. This has been called “the most profound discovery in science” and it is indeed impossible to understand quantum mechanics without understanding nonlocality. Unfortunately, it is a historical fact that Bell's theorem has been misunderstood by many physicists, leading to heated controversies that persist to this very day. The nonlocality of nonlocality also raises questions about the compatibility with Einsteinian relativity that are the subject of ongoing investigations.

Suggested References

John Stewart Bell. 2004. *Speakable and Unspeakable in Quantum Mechanics*. 2nd Ed. Cambridge: Cambridge University Press

Goldstein:2011ab

maudlin2014a

Dustin Lazarovici et al. 2018. “Observables and Unobservables in Quantum Mechanics: How the No-Hidden-Variables Theorems Support the Bohmian Particle Ontology.” *Entropy* 20 (5). <https://doi.org/10.3390/e20050381>

Norsen:2006ab

Online Lectures

- [Spooky Actions At A Distance?](#) by David Mermin.
- [What Did Bell Really Say?](#) by Jean Bricmont.

7.9. The Quantum Measurement Problem

Schrödinger's cat is not merely a funny story illustrating the weirdness of quantum physics. It is a formulation of the infamous *measurement problem* demonstrating the inconsistency of standard quantum mechanics. Understanding the measurement problem and its possible solutions leads to precise interpretations of quantum mechanics that draw a clear and objective picture of the microscopic world.

Suggested References

Maudlin:1995aa

Schrodinger:1983aa

Detlef Dürr and Dustin Lazarovici. 2020. *Understanding Quantum Mechanics: The World According to Modern Quantum Foundations*. Springer International Publishing

7.10. Interpretations of Quantum Mechanics

Quantum mechanics is an extremely successful physical theory, but what is the theory actually about? Nowadays, the old Copenhagen interpretation, based on a fundamental concept of “measurement” or “observation” and Bohr’s mysterious “complementarity principle”, is no longer taken seriously by the majority of physicists and philosophers of physics. Instead, there are several proposals on the table that ground the predictions of textbook quantum mechanics in a clear ontology and precise dynamical laws.

Suggested References

Travis Norsen. 2017. *Foundations of Quantum Mechanics: An Exploration of the Physical Meaning of Quantum Theory*. Undergraduate Lecture Notes in Physics. Cham, Springer International Publishing, 2017. <https://doi.org/10.1007/978-3-319-65867-4>

Detlef Dürr and Dustin Lazarovici. 2020. *Understanding Quantum Mechanics: The World According to Modern Quantum Foundations*. Springer International Publishing

Tim Maudlin. 2019. *Philosophy of Physics: Quantum Theory*. Princeton, Princeton University Press

7.11. Bohmian Mechanics

Bohmian Mechanics grounds the predictions of textbook quantum mechanics in a particle ontology and a nonlocal law of motion in which the quantum wave function enters. This theory has no measurement problem because a physical system has a well-defined spatial configuration determined by the position of its constituting particles. The usual quantum formalism, including Born’s rule and operators as “observables”, then arises from a statistical analysis of the theory. Although Bohmian Mechanics provides a clear and simple solution to the problems of orthodox quantum mechanics, it is still a very controversial theory.

Suggested References

Bricmont:2016aa

durr.teufel2009

Passon:2006aa.

Online Lectures

- [A video series on Bohmian mechanics](#).
- [Bohmian Mechanics: Speakable Quantum Physics](#) by Detlef Dürr.
- [Bohmian Mechanics](#) by Stefan Teufel.

7.12. The Many–Worlds Theory

The Many–Worlds Interpretation is the most radical reaction to the measurement problem. It accepts that macroscopic superpositions exist and that all states in such a superposition are equally real. This means, in particular, that after any quantum measurement, all possible outcomes are realized in different “worlds”. Conceptually, this theory is interesting because it tries to develop an objection description of physical reality from the wave function/ quantum state and its unitary evolution only.

Suggested References

everett1973

Maudlin:2014ad

Wallace:2012aa

Detlef Dürr and Dustin Lazarovici. 2020. *Understanding Quantum Mechanics: The World According to Modern Quantum Foundations*. Springer International Publishing.

Online Lectures

- [The Emergent Multiverse I: The Plurality of Worlds](#) by David Wallace.
- [The Emergent Multiverse II: The Probability Puzzle](#) by David Wallace.

7.13. Do Mathematical Objects Exist?

What are mathematical objects? Are they creations of the human mind or do they exist independently of us? Do mathematicians “discover” mathematical facts or rather “invent” them? What makes mathematical facts true in the first place, and how can we know about them? These questions are as old as mathematics itself and still relevant today. Influential positions include Platonism, Logicism, Structuralism, and Nominalism, but each account comes with different problems and challenges that are the subject of ongoing philosophical debates.

Suggested References

Brown:2008aa

Colyvan:2012aa

Friend:2007aa

kitcher1985

7.14. The Success of Mathematics in the Natural Sciences

In a now famous essay, Nobel-prize winning physicist Eugene Wigner wondered about the “unreasonable effectiveness of mathematics in the natural sciences.” This started a philosophical debate that persists to this day. Indeed, mathematics is not only the “language” of physics, it also plays a crucial role special sciences from chemistry to biology to social and economic sciences. How can this successes be explained, given that mathematics seems to be about purely abstract objects?

In 2015, the Foundational Questions Institute (FQXi) organized an essay contest “[Trick or Truth: the Mysterious Connection Between Physics and Mathematics](#)” aimed at top researchers in this field. There you can find some very good papers in addition to the references given below.

Suggested References

Wigner:1960aa

Alan Baker. 2005. “Are there Genuine Mathematical Explanations of Physical Phenomena?” *Mind* 114(454):223–238

Alan Baker. 2009. “Mathematical explanation in science.” *The British Journal for the Philosophy of Science*, 60(3):611–633

tegmark2008

7.15. Could Machines Think?

Computationalism is a position in the philosophy of mind. It holds that the mind is essentially a computational system. This implies, in particular, that any machine, running a sufficiently complex algorithm that implements the functional tasks of the human brain, would be conscious. On the other hand, several authors have argued against this view. With the rapid advances in quantum science and the rise of so-called “artificial intelligence”, this debate seems more relevant than ever.

Suggested References

chalmers2011

maudlin1989

penrose1999

searle1980

turing1950

7.16. Artificial Intelligence and its Consequences

With the rise of artificial intelligence, debates about the promises and risks of intelligent machines are more relevant than ever. Is an “intelligence explosion” inevitable? Will machines replace humans as the most powerful “species” on earth and if so, what does it mean for humanity? Should we fear or embrace superintelligent AI? And how could we control it? These are among the questions that this project can explore.

Suggested References

boden1990

bostrom2014

Stuart Russell. 2020. *Humanly Compatible: Artificial Intelligence and the Problem of Control*. Viking/Penguin Random House

Online Lectures

[Don't Trust the Promise of Artificial Intelligence](#). Debate by Intelligence Squared.

7.17. Is Free Will compatible with Laws of Nature?

It is an integral part of our self-image as human beings that we have free will, i.e., that we are the originators of our actions and can choose between alternative courses of action. The rise of modern science, however, gave rise to a tension: if the laws of nature hold strictly, then what room is there for free will, if any? Or does the purported problem suffer from a misconception of what laws of nature are? This project investigates these questions.

Suggested References

Alin C. Cucu and Brian Pitts. 2019. “How Dualists Should (Not) Respond to the Objection from Energy Conservation.” *Mind and Matter* 17(1): 95–121

Angus Menuge. 2009. “Is Downward Causation Possible?: How the Mind Can Make a Physical Difference.” *Philosophia Christi* 11(1): 93–110.

Michael Esfeld. 2020. *Science and Human Freedom*. Springer

Pieter Thyssen and Sylvia Wenmackers. 2020. “Degrees of freedom.” *Synthese*: 1-29

Jeffrey Koperski. 2017. “Breaking Laws of Nature.” *Philosophia Christi* 19(1) : 83-101

Richard Swinburne. 2013. *Mind, Brain, and Free Will*. Oxford: Oxford University Press. Chapter 5

7.18. Free Will and Neuroscience

In the 1980s, Benjamin Libet carried out his seminal experiments that explored the temporal relationship between a person’s intention to act and the onset of pertinent brain activity. His findings – and those of subsequent experiments in the same vein – are often taken to show that it is not us, but our brain, that acts. The question is whether this conclusion is justified, or more generally, how these results from neuroscience should be interpreted in regard to what they tell us about free will.

Suggested References

Alfred R. Mele. 2014. *Why Science Hasn’t Disproved Free Will*. Oxford, New York: Oxford University Press

Richard Swinburne. 2013. *Mind, Brain, and Free Will*. Oxford: Oxford University Press. Chap. 4.3

Joshua Shepherd. 2017. “Neuroscientific Threats to Free Will.” In: Meghan Griffith, Kevin Timpe, & Neil Levy (eds.). *The Routledge Companion to Free Will*. Routledge

Michael Gazzaniga. 2012. *Who’s in Charge?: Free Will and the Science of the Brain*. Hachette UK

Mark Hallett. 2007. “Volitional Control of Movement: The Physiology of Free Will.” *Clinical Neurophysiology* 118: 1179–92

7.19. Can Science Explain Consciousness?

Physicalists believe that everything that exists is physical, which includes consciousness. Thus, physicalists must offer an explanation of how conscious states can be analyzed wholly in terms of physical states. The wider group of naturalists believe that even if consciousness is non-physical, its generation must be scientifically explainable. Which one of these views, or whether a non-naturalistic take on consciousness, has the upper hand, is the question to be addressed in this project.

Suggested References

David Chalmers. 1996. *The Conscious Mind*. New York: Oxford University Press

David Lewis. 1972. "Psychophysical and theoretical identifications." *Australasian Journal of Philosophy* 50(3): 249-258

Jaegwon Kim. 1998. *Mind in a physical world: An essay on the mind-body problem and mental causation*. MIT press

William Hasker. 1999. *The Emergent Self*. Ithaca: Cornell University Press. Chap. 1-2

David Papineau. 2000. "The Rise of Physicalism." In: M. W. F. Stone and J. Wolff (eds.) *The Proper Ambition of Science* New York: Routledge. 174–208